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PERFORMANCE OF THE TRANSITION ANALYSIS PROGRAM SYSTEM ON THE AD--ETC(U)
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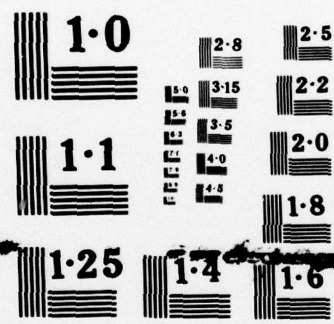
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Performance of the Transition Analysis Program System on the Advanced Scientific Computer,

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Transition Analysis Program System (TAPS) has been implemented on the Advanced Scientific Computer (ASC) at NRL. No changes in the original program have been made to take advantage of the pipeline architecture of the ASC, but some vectorization of the code is performed by the computer. Comparisons of computational results, run times, and costs of flow problems solved with TAPS on the ASC and other computational facilities are presented and their significance discussed.

PERFORMANCE OF THE TRANSITION ANALYSIS PROGRAM SYSTEM ON THE ADVANCED SCIENTIFIC COMPUTER

INTRODUCTION

During the past three years the Naval Sea Systems Command (NAVSEA 03) has sponsored the development by McDonnell Douglas Corporation of a large and quite general computer code for the analysis of flows around submerged bodies. It includes the potential flow analysis, boundary layer solution, and prediction of the growth rate of disturbances in the laminar boundary layer (from which the location of the laminar-to-turbulent transition can be predicted). Users of the code, called the Transition Analysis Program System (TAPS), have reported that it is undesirably expensive to run on conventional computers. Therefore, work has been initiated at the Naval Research Laboratory (NRL) to investigate possible cost reductions by using its Texas Instruments Advanced Scientific Computer (ASC), a "pipeline" machine. This work is potentially beneficial to fluid dynamicists at a number of Department of Defense installations by virtue of their access to the ASC through the Defense Advanced Research Projects Agency Network and anticipated access through the Navy Laboratory Computer Network (NALCON).

The present report summarizes work done to date with TAPS on the ASC. Each of the 106 subroutines of TAPS has been compiled with the

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vector (NX) compiler; and the axisymmetric potential flow, laminar boundary layer, and transition portions of the code have been tested with sample problems. Comparisons of the results, run times, and costs with those obtained at other computational facilities have been made where possible, allowing an assessment of the advantages of using TAPS on the ASC.

REVISIONS OF THE CODE FOR ASC USAGE

An IBM-compatible version of TAPS was provided by NAVSEA. The following changes were made for ASC usage: (a) a number of constants which were undefined in the original code such as NTYPE, were either eliminated or set equal to zero; (b) calls to IBM subroutines, such as ERRSET, were eliminated; (c) the write statements to Tape 17 in subroutine FLOWS were changed from formatted to unformatted to be consistent with the remainder of the program; (d) the READ and WRITE statements to Tape 23 in subroutines STAB, OTPT, and INP2 were changed from formatted to unformatted.

Subroutines were compiled at the K level of optimization except where difficulties in compilation or execution ensued. Subroutine OSI had to be compiled at the I level, for example, because higher level compilations introduced errors by vectorizing short DO loops with complex arithmetic operations. It must be emphasized that no changes have been made to date in TAPS to facilitate vectorization. Thus, while a significant amount of vectorization was done by the compiler, much more would be possible by altering portions of subroutines to facilitate this operation.

SAMPLE PROBLEM ONE

This problem was used by McDonnell Douglas to test TAPS. It consists of the analysis of the flow around an axisymmetric body of approximately 4.3 m length. The maximum diameter of approximately 0.52 m is 2.7 m from the nose, and a weak positive pressure gradient and a heated wall are present over most of the forebody. The program was used to generate the potential flow solution around the body, predict the laminar boundary layer characteristics forward of laminar separation, and determine the spacial amplification ratio of selected disturbances to the laminar boundary layer at a freestream Reynolds number per meter of 1.125×10^7.

The potential flow and boundary layer solutions of this problem generated by the ASC were essentially identical to those obtained previously at other computational facilities. Excellent agreement was also realized in the values of spacial amplification ratios computed on the ASC and elsewhere. Table 1 shows the amplification ratios computed for particular stations (axial locations on the body) and normalized disturbance frequencies on three computers. Similar correspondence in the computed ratios has been verified at other stations and frequencies.

Detailed run time and cost comparisons have been made between the ASC and the CDC 6600 system at the David W. Taylor Naval Ship Research and Development Center. Table 2 shows shorter run times on the ASC and Table 3 shows greatly reduced run costs. Results have been shown with

TABLE I

Comparison of Computed Amplification Ratios (Sample Problem One)

	Station	Frequency	Amplification Ratio
CDC 6600	27	$.460\text{X}10^{-4}$	exp(1.94)
	51	$.180\text{X}10^{-4}$	exp(3.75)
IBM 370	27	$.461\text{X}10^{-4}$	exp(1.93)
	51	$.180\text{X}10^{-4}$	exp(3.78)
TI ASC	27	$.461\text{X}10^{-4}$	exp(1.92)
	51	$.180\text{X}10^{-4}$	exp(3.78)

TABLE 2

Run Times for TAPS

(Sample Problem One)

	Potential Flow	Boundary Layer Flow	Stability Analysis	Total
CDC 6600*	17(Sec)	57	176	250
TI ASC*	13	32	91	136
TI ASC**	13	19	65	97

*formatted Tape 23
**unformatted Tape 23

TABLE 3

Computational Cost Comparison

(Sample Problem One)

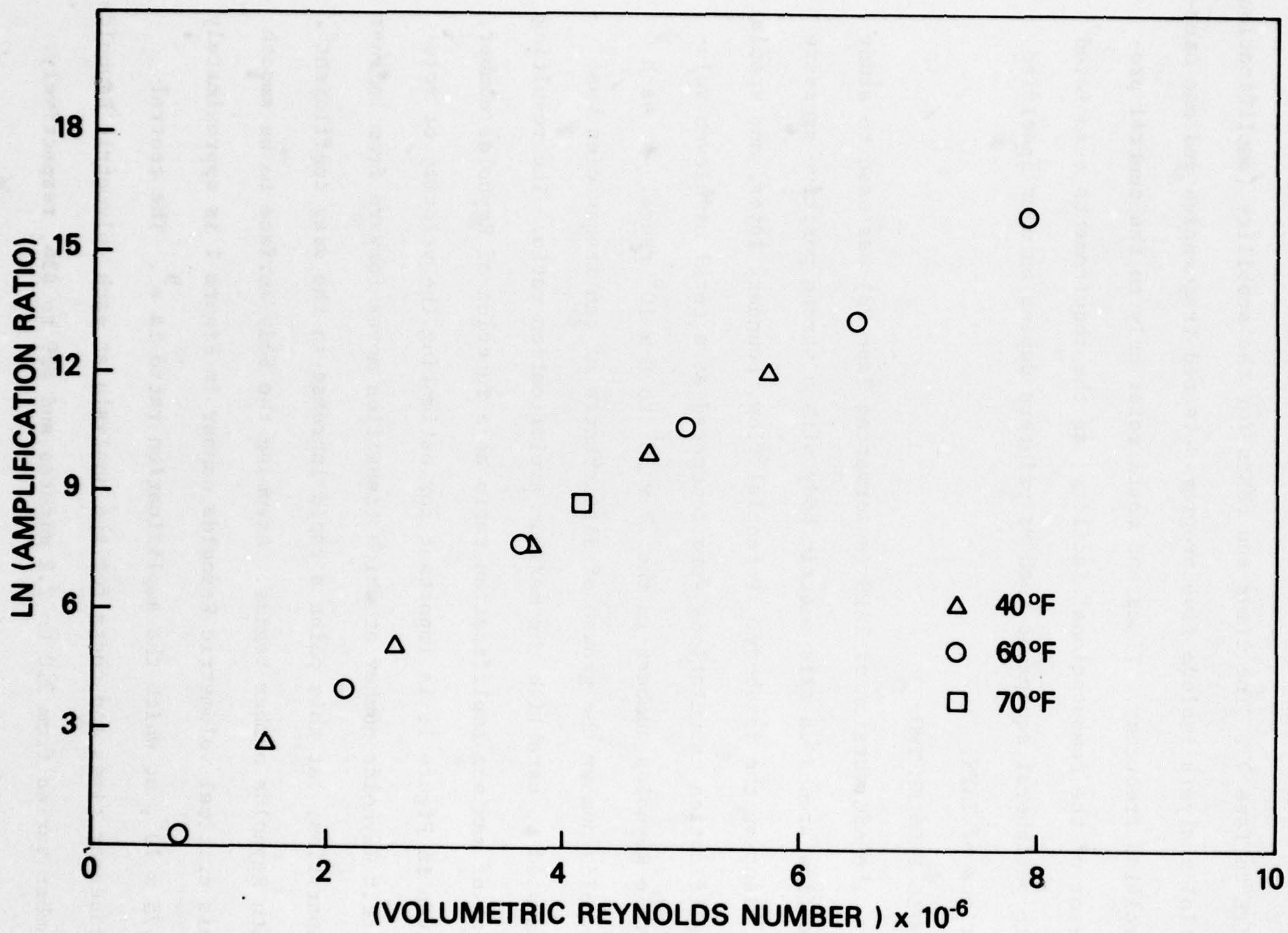
	Potential Flow	Boundary Layer Flow	Stability Analysis	Total
CDC 6600*	$12	31	72	115
TI ASC*	3	8	21	32
TI ASC**	3	5	15	23

*formatted Tape 23
**unformatted Tape 23

both formatted and unformatted Tape 23 runs for the ASC, while CDC 6600 time and cost information are available only with a formatted READ and WRITE to Tape 23. The times and costs for the stability (amplification ratio) analysis include five program-selected frequencies and one user-specified frequency. Times and costs refer only to the central processor of the computational facility, as the requirements associated with peripheral equipment such as printers depend on user-specified options of TAPS.

SAMPLE PROBLEM TWO

The ASC version of TAPS (unformatted Tape 23) was used to study the flow around an axisymmetric body with a strong positive pressure gradient on the forebody. Potential flow, boundary layer, and spacial amplification calculations were conducted at a total of eleven volumetric Reynolds numbers in the $.7 \times 10^6$ to 8×10^6 range. At each Reynolds number the growth of disturbances of ten frequencies was computed to establish the maximum amplification ratio. The resulting plot of maximum amplification ratio as a function of Reynolds number, given in Figure 1, is important for estimating the velocity or volumetric Reynolds number at which transition moves forward from laminar separation. At this point a rapid increase in the drag coefficient with Reynolds number begins. Assuming the body surface to be smooth this critical volumetric Reynolds number in Figure 1 is approximately 4.25×10^6, at which the amplification ratio is e^9. The central processor times and costs for the analysis at each volumetric Reynolds number varied from 2.0 to 2.2 minutes and $29 to $34, respectively.


LN (AMPLIFICATION RATIO)
18
15
12
9
6
3
0
2
4
6
8
10
(VOLUMETRIC REYNOLDS NUMBER) x 10^-6
40°F
60°F
70°F
Figure 1

DISCUSSION AND CONCLUSIONS

The work reported herein has established the TAPS can be used much more economically on the ASC than on other Navy computational facilities. Substantial further improvement may be realizable by rewriting selected subroutines to increase the amount of vectorization. The performance of the two dimensional potential flow and turbulent boundary layer portions of TAPS on the ASC remain to be established.

ACKNOWLEDGMENTS

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